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has arisen towards the conclusion of the period of wood-forming activity." It was found that in the broad-leaved trees examined no increase in thickness took place until the buds had opened and the first leaves expanded; that the first formation of new wood was in the neighborhood of the terminal bud; that the first growth was not continuous around the stem, but of vessels and tracheids in irregular groups; that the growth was continued gradually from the one-year twig to the two- and three-year twigs; and that when the new wood begins to form on five- and six-year twigs the process becomes very rapid, seeming as if at that time growth began simultaneously over the whole tree. Growth usually begins and extends more rapidly on the upper more exposed limbs sometimes a week before any sign of growth can be seen on the lower limbs. In the pine an apparent exception was found, for increase in thickness began on two- and three-year twigs before it began on one-year twigs and before the buds had opened. By the time the buds were well opened the growth had extended from the terminal shoot down the trunk and growth was just beginning on the lower branches. This seems to be due to the leaves remaining on the twig for two or three years. In the hemlock, which holds its leaves for six or seven years, the growth, when examined about the end of May, was greatest on six-year twigs and decreased up to the one-year twigs where the growth was slight. On one of the deciduous Gymnosperms, the bald cypress (*Taxodium distichum*), the conditions seem to be as in the broad-leaved, deciduous trees; no growth in thickness begins till the leaves are expanded, and then it begins at the younger branches and extends back to the older ones.

On the Assimilation of some Organic Substances by Plants: By J. F. CLARK.

The Rheotropism of Roots: By F. C. NEWCOMBE.

North American Sordariaceæ: By DAVID GRIFFITHS.

The Development of the Egg and Fertilization of Pinus Strobus: By MARGARET C. FERGUSON.

Nuclear Division in the Hepaticæ: By B. M. DAVIS.

The History of the Bulbils of Lysimachia terrestris L.: By D. T. MACDOUGAL.

Observation on Root Hairs: By W. J. BEAL.

The root hairs of *Agrostemma Githago* L. and *Lilene notiflora* L. arise in vertical rows of epidermal cells, and those of the former are always extensions of the apical end, while they arise in the middle of cells in other species. Great variations in size and form were found, and septate hairs were seen on *Chenopodium hybridum*. Root hairs are extremely sensitive to changes of temperature and moisture.

D. T. MACDOUGAL,
Secretary.

THE FAITH OF SCIENCE.*

It has been said that each man has one thing to say, and that when he speaks twice he repeats the second time what he said the first. I hope that the saying is not wholly true; and yet I fear that in my case there is a grain of truth in it. I was invited to speak a year ago to the Graduates' Club, and I suspect that I then said much that I am always tempted to say to graduate students. However, as your Dean has, for lack of better available material, invited me to address you at this your first meeting of the year, I must say something; and so I shall take down again the old fiddle, and give you what some of you will recognize as merely a variation upon the old tune.

* An address before the Graduate School of the University of Pennsylvania.

Several times this summer there has come into my mind a passage from an early work by Ernst Renan, in which he impresses one with the fact that it is melancholy to contemplate the bewildering masses of monographs with which the increasing specialization on the part of scholars threatens to flood the world.

Upon returning to the University this fall, and turning over the leaves of the new journals, the new books and the off-prints sent me by various friends and correspondents, I am impressed anew by the thought that, in every field of science, the swelling mass of material is indeed bewildering—I will even say appalling—and that the amount of attention that it is possible for any of us to bestow upon much of it seems a poor repayment to the author for his days and nights of a labor usually but poorly requited in the current coin of the realm. I am not speaking of papers printed for the sake of printing, precipitately created out of nothing at the fiat of a restless desire to keep one's self in evidence—the 'let there be noise,' which results in thunder not preceded by the illuminating flash. I speak of earnest efforts to add a little to the sum of human knowledge—a new historical fact dragged from some obscure and out of the way corner by a man who thinks it not without significance; an odd case of the use of the dative in mediæval Latin; a set of experiments, of perhaps doubtful import, on the borderland which separates psychology from physiology; a description of some rather uninteresting beetle; or an analysis of the argument of some equally uninteresting philosophical writer. Of printing for print's sake, many of you know my opinion. But what shall we say touching the numberless publications over which their authors have spent blood and sweat, and which seem to be read chiefly, if at all, by the ungrateful reviewer? When so few care to listen to the song,

"What boots it, with incessant care,

* * * * *

To strictly meditate the thankless Muse?"

I speak to those who expect to devote their lives to science, and who, if they have within them any grain of modesty, will probably sometimes feel inclined to ask themselves seriously whether human life is really enriched in any appreciable degree by the fruit of their labors.

There have been ages in the world's history when such questionings would not so naturally have arisen. The many-sided intellectual curiosity which accompanied the new awakening of the world in the fourteenth and fifteenth centuries, did not find it necessary to enquire whether it 'paid' to establish the text of Cicero or to speculate touching the significance of Plato's *Timæus*. The greater the number of the intellectual enthusiasms alive at a given epoch, the less the likelihood that such a doubt as I have mentioned should arise in any given field. At every age, it is generally assumed that something or other is of importance, and the judgment of the age supports and incites to activity even the humblest worker in that particular field. Who would to-day think of doubting the value of the invention of a new air-brake, the discovery of a new process for obtaining dye-stuffs, or the devising of a new mechanical contrivance for quieting the baby. But scholars who spend their time upon matters which seem to have no connection with such things as these, are, perhaps naturally, called upon, from time to time, to give an account of their stewardship, and not infrequently have reason to doubt whether their contemporaries view their labors as of any value at all. No one likes to stand alone. He who is doubted comes to doubt himself; and he may even come to work in the half-hearted way natural to one without the enthusiasm which is born of faith.

What can I say to you in the face of

these things? Can I prove that every historical fact which may be discovered will be found to have a directly practical ethical or political significance? Can I show that all psychological experimentation is capital in the hands of the pedagogue? Does the discovery of every new beetle prove a boon to the agriculturist or to any one else? Are all philosophers so inspired that we may assume their words to be of value, whether we understand them or not? Manifestly, I can not prove these things, or show in just what respect human life has been enriched by a multitude of seekers after truth who have, perhaps, really succeeded in adding their modicum to the sum total of our knowledge.

Nor do I stand here with any desire to prove such things. The thought which I wish to bring before you is a very different one. It is that it is in no way incumbent upon you to give such a proof, or to torture yourselves with the idea that you must daily justify your labors by the exhibition of what is often called their practical importance. Science and letters would come to a sorry pass if it were regarded as indecorous for man to look upon the naked truth, and if she were held to be a fit object of contemplation only when bundled up in her working clothes and busied about the hearth or the loom. A too narrow attention to what is commonly called 'the practical' would sap the very foundations of progress; would defeat its own ends by cutting off that light which is our final guarantee of life and growth. Shall we close some of the windows in the house of life because this or that age prefers to have its light filtered through a particular medium? What may be the needs of man, the direction of development of society in the ages to succeed our own? Who can tell what knowledge will be found to be of the profoundest moment to those who come after us? Shall we, in our littleness,

shut our eyes on the living miracle about us, except at such times as its light reveals just those objects which seem providentially intended for our particular dinner-pail? Some nonsense has, to be sure, been talked about 'truth for truth's sake'; 'truth,' we are apt to object, 'for the sake of life.' But in the larger faith of science, that faith without which the world could not have been where it now is, there is no truth that may not be of value to life; no truth that is not worthy of our highest endeavor.

Perhaps it will be admitted that truth should be sought in a generous spirit, and that, in the history of the human race, the army of those who have peered curiously into the mysteries of human life and the nature of things has played a part that cannot be overestimated. We have, it seems to me, a right to demand so much, at least, of all intelligent men. But the question remains: What can we say touching the individual value of the numberless units that have tramped wearily in the ranks? That the great captains have accomplished something notable few will deny. They have conquered the fair lands that we now cultivate. But how of the common soldier, whose very name is unknown, except to the few who busy themselves with the dusty records of an almost forgotten past, and love to loiter in the by-ways of curious learning? Has he existed to no purpose? Has he toiled in vain?

Surely not. He has done what he could. He has contributed his little to the enlightenment of the race; and out of his very errors, his perplexed and rather aimless marchings to and fro, there may have come a result he little expected and as little hoped. Only he who knows something of the history of human knowledge knows with what pangs of labor the modern world has been brought to the birth. It is an ancient fable that makes Minerva spring fully armed from the head of Jove. Not thus is knowl-

edge born. Human enlightenment is a thing of small beginnings; it is the outgrowth of the life of the race, not the magical creation of a few master minds. Many hands have labored to rear the great edifice, and he who has carried a single stone, even a small one, has not lived in vain.

"Nevertheless," one may whisper, "What if that stone should turn out to be no stone at all, but a clod of earth, and of no value to the building?" I answer: that is not your affair nor mine. Nature is prodigal of the means by which she attains her ends. We share with men in other walks of life the uncertainty as to the ultimate value of our particular labors. It is plainly necessary that there should be physicians and lawyers, and the rest; yet in view of the ignorance which hems us in, in view of the nearness of our horizon and the impossibility of predicting with certainty the remote consequences of human actions, who can dare to estimate the total accomplishment of this life or that? We are a part of a great whole; we must share in the life of the whole; and those of us who are striving to carry our little grain of truth to the common board must rejoice in the wealth of the community, not grow despondent at the smallness of our contribution.

Let me invite you, then, to enter with joy upon your scientific labors. You can be called to no nobler work, and you must approach it in no doubting spirit. You must be inspired with a reverence for truth, and a faith in its priceless value for human life, that will carry you over periods of doubt and despondency; a faith that will gild with its mellow light the dry dust of your daily labor, and cast a ray into even those darker chambers in the blind walls of which you, with others, are striving to open a passage to the light of heaven.

And if you have this faith it will save

you from that scientific intolerance which is not more tolerable than intolerance of other kinds. Do not narrow the meaning of the word 'science.' Let it be a synonym for openness of mind, patience, freedom from prejudice, a willingness to see the beauty and admit the importance of truths of many kinds. Do not undervalue the toil of men who delve in obscure corners of fields far remote from your own. The universe is, after all, but one; there is but one science, in the broadest sense of the word. The vibration of an atom, the unfolding of a flower, the structure of a mollusc, the instinct of a brute, and the reason of a man—what is there that does not call for investigation? If I may study the history and trace the development of a group of plants, why may I not investigate, in the same scientific spirit, not merely a group of languages, but a literature or a philosophy? This truth or that truth must not, in our minds, usurp the name of Truth; and the cause of science is not furthered by an enthusiasm which fails to see how many-sided truth is, and with what different instruments one may do good work in different departments. I lay some emphasis upon this point because, with increasing specialization—the natural result of an increase in human knowledge—there goes a certain danger. We cannot all work in all fields, of course; but if we have the truly scientific spirit, we shall value at its real worth faithful work done in every field. Fortunately for you, your association with each other here at the university will tend to open your eyes to the beauty of towers and pinnacles on the edifice of knowledge, which are taking their shape under other hands than your own.

In the name of my colleagues I bid you welcome to the work of the university; and I wish you a full measure of success.

GEORGE STUART FULLERTON.

UNIVERSITY OF PENNSYLVANIA.